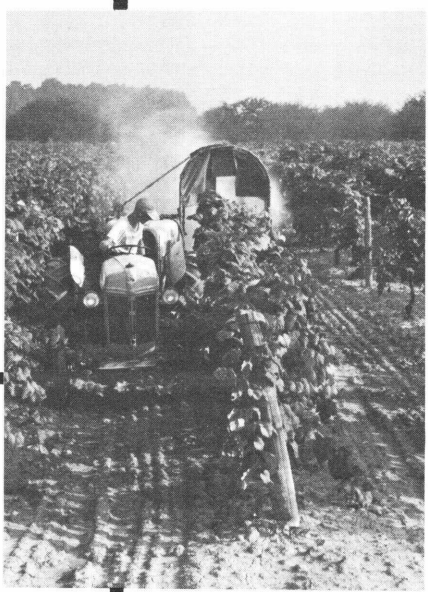
CONTROL OF GRAPE DISEASES AND INSECTS IN THE EASTERN UNITED STATES



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CONTENTS

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CONTROL OF GRAPE DISEASES AND INSECTS IN THE EASTERN UNITED STATES

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Damage to grapes in the Eastern United States by diseases and insects varies considerably in different regions and from year to year.

Weather conditions during critical periods for infection affect the development and spread of organisms causing grape diseases and, therefore, the number of sprays needed and the intervals between them. In some years one or two applications of a fungicide may be sufficient; in other years the general spray schedule (p. 26) is inadequate. An understanding of the diseases and organisms that cause them will enable you to adapt the schedule to your particular needs.

Grape diseases generally are more prevalent and difficult to control in the Southeastern States because of prevailing high temperatures, abundant rainfall, and long growing season. The varieties of grapes grown influence the amount of disease. The vinifera, or European, varieties are very susceptible and cannot be grown successfully east of the Rocky Mountains, except in a few favorable districts. Varieties of the American bunch grape vary as to susceptibility to disease, whereas, muscadine grapes are highly resistant to the more destructive diseases.

Grapes are subject to attack by many kinds of insects. Only a few of the economically important insects are discussed in this bulletin.

The general spray schedule (p. 26) is intended for average conditions and usually will be adequate in controlling the diseases and insects most commonly encountered. For precautions concerning the handling and use of pesticides, see page 22.

DISEASES PRINCIPALLY OF AMERICAN BUNCH GRAPES

BLACK ROT

Black rot, a fungus disease, is the most widespread disease of grapes.[1] In the eastern grape-producing districts, it causes greater loss than all other diseases combined. Black rot is generally distributed east of the Rocky Mountains, but it is most prevalent and destructive east of the Mississippi River. It is especially destructive in the hotter, more humid parts of this region.

All vinifera varieties of grapes and many of the American bunch grapes are highly susceptible to black rot.

The following varieties of American bunch grapes are moderately resistant to black rot and are of fair to good quality: Beta, Campbell Early, Clinton, Delaware, Elvira, Lutie, Missouri Riesling, Moore Early, Norton, Portland, Sheridan, and Worden.

The black rot fungus attacks the leaves, young canes, tendrils, and fruit. Only the youngest tissues are susceptible, except for the fruit, which may become infected until it is almost fully grown. Rotting of fruit after it begins to color is generally caused by other fungi.

About 2 weeks elapse between the time of infection and the appearance of typical spot symptoms. Although spotting occurs on the leaves

[1] The causal organisms of grape diseases are given on p. 28.

(fig. 1) and vines early in the spring, it usually goes unnoticed until midsummer, when the nearly half-grown berries begin to discolor and dry.

Symptoms of rot on the berries first appear as light-brownish, soft, circular spots. The spots enlarge rapidly and, within 2 or 3 days, discolor the entire berry. The decaying berries soon shrivel and, in 7 to 10 days, change to black, hard, wrinkled mummies, which may remain attached to the bunch (fig. 2). The mummified berries are covered with barely visible pimplelike structures, which produce infective spores. These structures may also be seen in the spots on the leaves, tendrils, and canes.

The extent of the disease from season to season depends, in part, on favorable weather conditions during spring and early summer. Primarily, however, it depends on the amount of diseased material that is carried over on the vines, on old infected tendrils on the trellis wires, and on fallen leaves, as well as on diseased fruit from the previous season. New spores are produced during warm, moist weather in the spring on such old infected plant parts and these infect young leaves and shoots.

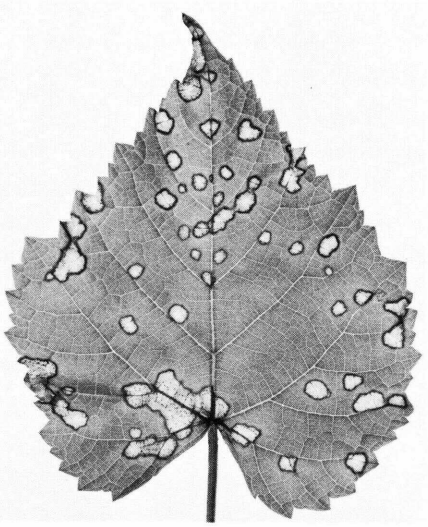

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Figure 1.—American bunch grape leaf attacked by black rot fungus.

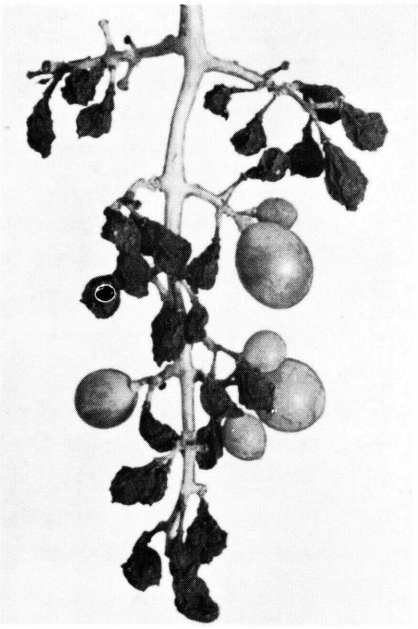

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Figure 2.—Cluster of grapes showing black rot injury. Note mummified berries.

If the vines are not sprayed early with the proper fungicide, the fungus may attack the young shoots and leaves and build up a reservoir of spores capable of infecting the fruit later in the season. Exact timing of the spray immediately after bloom (spray 3) is very important, particularly when rainfall or dew occurs during or immediately after bloom.

The choice of fungicides for black rot depends on the disease hazard in the area, ease of preparation, cost, and size of the planting.

Ferbam will control black rot, but it is ineffective against downy mildew.

Bordeaux or copper-lime mixtures will control black rot and downy mildew. However, these materials can damage young leaves and stems.

Zineb is almost as effective as bordeaux mixture against both fungus diseases and is less harmful to young leaves and stems. Because zineb is easy to prepare, it is generally recommended for small vineyards.

Captan is used by some growers.

DOWNY MILDEW

Downy mildew, a fungus disease, primarily attacks grape leaves. It damages the leaves in unsprayed vineyards in the Ohio River Valley, the Great Lakes region, and the Northeastern States as far south as southern Virginia. Since the disease is more severe in cool, moist weather, it is of minor economic importance in the South.

Older leaves in the center of the vine are the first to become infected. The disease spreads toward the leaves at the end of the canes as they mature. By autumn, on highly susceptible varieties, even young leaves may die and fall. If the season has been unfavorable for the spread and rapid growth of the fungus or if the grape variety is resistant, only a few of the oldest leaves may show the symptoms.

The fungus overwinters on old diseased leaves on the ground. Weathering and decomposition free the spores in spring, and splashing rain or wind causes some of them to reach the new leaves or the berries, where infection starts. Damage to the leaves, usually minor before late summer, is greatest during August and September.

First signs of infection on the leaves are light-yellow spots. Then a white moldy growth of fungus threads and spores forms on the undersides of the leaves (fig. 3). The spots may be few or many. When they merge, they can cover most of the leaf. The affected leaves eventually turn brown, become dry and crumpled, and fall. The exposed berries may be scalded by the sun, or, if the vines lose their leaves before the ripening season, berries do not mature normally.

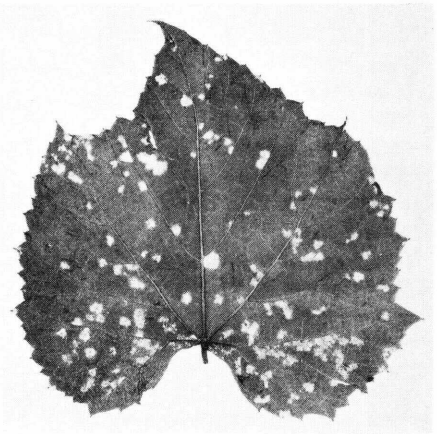

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Figure 3.—Downy mildew on underside of grape leaf.

Downy mildew may also attack and cause severe malformation of shoots, tendrils, or berries early in the season when they are tender (fig. 4). Early symptoms on these parts appear as water-soaked depressions; and later, a white moldy growth may develop.

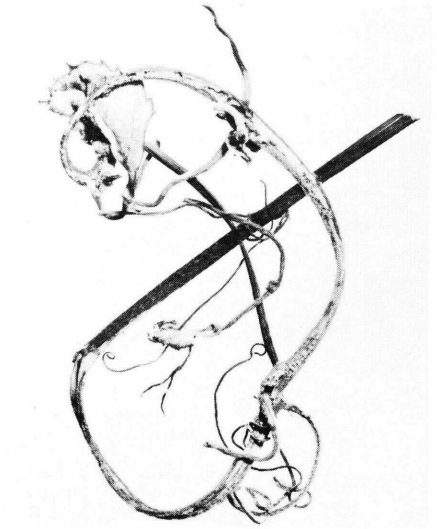

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Figure 4.—Tips of grapevine killed by downy mildew.

In years when the berries are attacked by downy mildew, there can be two waves of infection during one growing season. The first is in June, when the berries are about the size of small peas. When the berries are infected at this period, they become soft, shatter easily, and frequently are covered with a white downy growth (fig. 5). During the hot part of summer there is less evidence of mildew rot, but when nights become cooler, the second wave of infection may occur. Berries infected at this time generally do not soften and have the downy growth; instead they become brownish, wither, and shatter easily.

Downy mildew of grapes is comparatively easy to control. It seldom causes damage in vineyards that are sprayed regularly for protection against black rot with bordeaux mixture. Ferbam, which is effective against black rot, will not control downy mildew. Captan or zineb may also be used to control downy mildew. See the general spray schedule (p. 26).

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Figure 5.—Downy mildew on young grape berries. (Courtesy Department of Plant Pathology, Cornell University.)

ANTHRACNOSE OR BIRD'S-EYE ROT

Anthracnose, a fungus disease, occurs in some sections of the Northeastern and Southeastern States, but it usually is localized and confined to a few varieties. The disease can do considerable damage in a vineyard or a locality for a few years—and then disappear.

Anthracnose has seldom been found on the Concord variety. Other highly resistant eastern varieties are Beacon, Delaware, Herbemont, Lutie, Moore Early, Niagara, and President. The most susceptible varieties are Campbell Early, Catawba, Champion, Diamond, Diogenes, Ellen Scott, Norton, and Salem.

The effect of the disease on the berries and other parts of the vine is rather striking. This disease is not easily confused with other grape diseases. The berries, young shoots, tendrils, petioles, leaf veins, and fruit stems may be attacked severely.

Numerous spots sometimes occur on the young shoots. Some of these spots combine and cause girdling, which kills the vine tips. Similar spots develop on the petioles and leaves, especially on the undersides of leaves. Badly infected leaves curl downward and become spotted. The spotted tissues eventually drop out.

Spots on the berries are circular, sunken, and ashy gray. In the late stages of the disease the spots have a dark border. The name "bird's-eye rot," sometimes applied to this disease, is derived from the appearance of the spots on the berries (fig. 6).

To control anthracnose, use a spray that contains one part of concentrated lime-sulfur to nine parts of water during the dormant sea-

son. Follow this with four or five applications of bordeaux mixture or ferbam as for black rot (p. 26). Remove and burn all affected parts of the plant as they appear.

RIPE ROT AND BITTER ROT

Other fungus rots that attack the berries when they begin to mature are ripe rot and bitter rot. No clear-cut symptoms distinguish these diseases, except that the bitter rot fungus gives a bitter taste to decayed berry pulp.

These diseases are not troublesome in well-sprayed vineyards, if the general spray schedule for black rot is followed (p. 26). Since these diseases do not appear until the grapes begin to mature, the late fungicide sprays for controlling black rot and downy mildew are necessary to protect the berries during the ripening season.

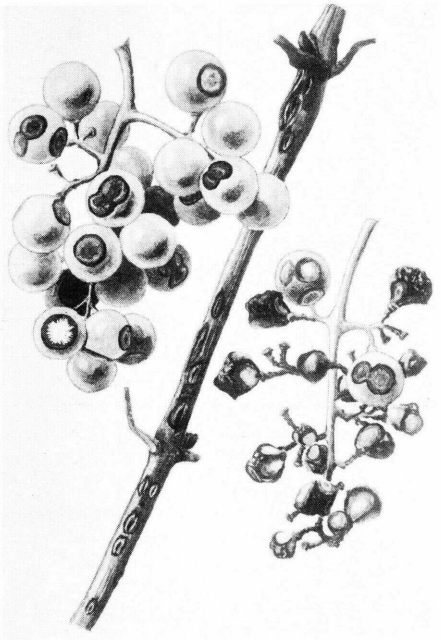

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Figure 6.—Anthracnose on fruit and vine of grape. (Photographed from painting by J. M. Shull.)

DEAD ARM

Dead arm, a fungus disease, occurs throughout the Northeastern States, where it attacks the trunk and main branches of the vines, primarily. Although it can also attack young canes and leaves, damage to these parts of the plant is less severe.

Entering the trunk and main branches through wounds caused by pruning or winter injury, the fungus lives in the woody tissues as a perennial parasite. There it infects and kills tissues, causing a canker to form. The canker enlarges each year until it finally girdles the trunk or main branches. Girdling kills the part of the vine above the canker. And although a new shoot may develop near the canker, it usually is weak and has yellowed and cupped leaves. It generally dies the following winter.

Symptoms on the canes and leaves first appears as small dark spots. As the canes grow, the spotted tissues may split. These symptoms appear in early spring and, although not economically important, indicate that dead arm is present in the vineyard.

To control dead arm, cut off the diseased parts below the canker. Remove the cuttings from the vineyard and burn them.

A delayed dormant spray of bordeaux mixture (8:8:100) will protect against dead arm. Or use 2 sprays of captan. Prepare the captan spray by mixing 4 pounds of captan to 100 gallons of water. Apply it at 50 gallons per acre when new shoots are 1 to 2 inches long and again when the shoots are 4 to 6 inches long.

POWDERY MILDEW

Powdery mildew is a fungus disease that occurs in many vineyards, but it is of little economic importance in the Eastern States.

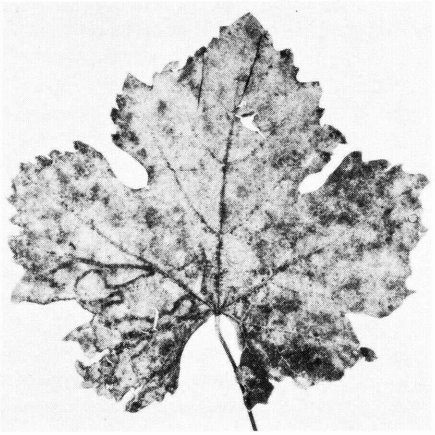

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Figure 7.—Powdery mildew on upper side of grape leaf.

East of the Mississippi River, powdery mildew is largely a disease of the foliage and cluster stems. It appears as a white, powdery growth on the leaves and other green parts of the vine (fig. 7). Severely affected leaves turn brown and fall. If the berries are infected, they appear rusty or scaly. They fail to mature properly and may split following a rain. Infection of the cluster stem may cause shelling of the ripe fruit.

On varieties that are only slightly susceptible to powdery mildew, such as Concord, or on susceptible varieties that will not tolerate sulfur sprays, use bordeaux mixture or fixed copper in the regular spray program to help control the disease.

On susceptible varieties that are tolerant of sulfur, the disease can be controlled with a spray that contains wettable sulfur. Apply the spray two or three times early in the season at the rate of 5 to 10 pounds per acre. Unless you know a variety is tolerant of sulfur, do not spray it with sulfur, because severe defoliation—particularly in hot weather—may result.

ROOT DISEASES

The roots of grapes are attacked by several organisms that cause swellings or decay. Root diseases are not easily detected. It is often necessary to remove a plant or part of the root system from the soil to examine it for suspected root diseases. In general, the symptoms of root diseases are: slow growth of the vine, low productivity, small, scant, yellowish leaves, and wilting.

To prevent root diseases, plant vines that have disease-resistant root stocks. Ask your county agricultural agent or State agricultural experiment station specialist for advice on choice of rootstocks.

Crown Gall.—Although not a serious grape disease in the Eastern States, crown gall is conspicuous on the vines when it occurs. It is caused by a bacterium that is a wound parasite of the roots and trunk. Infected roots develop large spherical galls, usually near the ground line. Sometimes they become as large as walnuts (fig. 8). The crown gall organism is widely distributed and attacks various fruit trees and shrubs.

Because this organism lives in the soil, it cannot be controlled by spraying. When galls are confined to the branches or trunk, remove all affected tissue; make cuts at least 2 inches below the gall. Examine new plants before planting, and discard any that have galls.

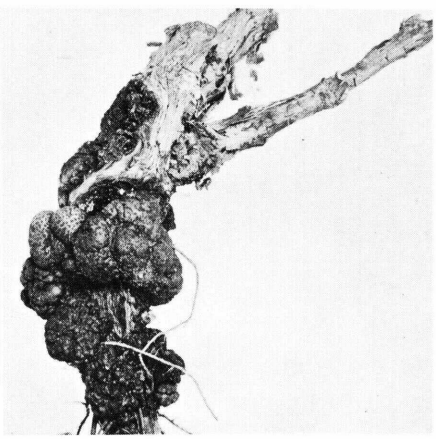

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Figure 8.—Crown gall on grape root at surface of soil.

PIERCE'S DISEASE

This virus disease is spread by several species of sharpshooters, or large leafhoppers. It is widespread throughout the Southeastern States. Much of the degeneration in American bunch grape plantings in these States is attributed to Pierce's disease.

Muscadine grapes and the varieties Lake Emerald and Blue Lake are very tolerant of the virus. Older American varieties that are tolerant of Pierce's disease include Champanel, Herbemont, and Lenoir.

Symptoms of this disease differ widely, depending on the season and the variety. They include (1) delayed foliation, (2) dwarfing of shoots, (3) marginal dying of leaf tissue, (4) wilting or premature coloring of fruit, (5) uneven maturity of canes, and (6) gradual dying of root system and degeneration of vine.

Pierce's disease causes obvious damage only in the Gulf States. Once a vine is infected, there is no cure. However, damage from this disease can be prevented or reduced by using varieties that are tolerant of the disease and adapted to the area.

OTHER VIRUS DISEASES

Several other virus diseases occur on grapes. They affect only certain varieties—particularly those with considerable vinifera parentage—and may not produce obvious symptoms. Among the symptoms are premature scorching of leaves in the fall, delayed maturity of fruit, reduced sugar content of fruit, and general reduction in vigor and productivity of vines.

Once a vine is infected with a virus, there is no cure. Propagations from such a vine will carry the virus. Select only the most productive vines for propagation.

DISEASES OF MUSCADINE GRAPES

BLACK ROT

The fruit of such muscadine varieties as Hunt, James, Mish, Scuppernong, and Thomas is relatively free of diseases. Black rot, the most damaging fruit disease of American bunch varieties, causes minor damage to the fruit of muscadine varieties. Although infection by black rot does not cause decay on muscadines, it results in a black, shallow, scablike defect (fig. 9).

However, the blossoms are susceptible to black rot. A few days of cloudy, rainy weather during the blossoming period will favor infection and sometimes will result in a heavy drop of blossoms. Black rot causes heavy spotting on the leaves of muscadine grapes. In seasons favorable for the fungus, the spots are rather conspicuous and numerous, and a large part of the leaf usually is destroyed (fig. 10). The leaves of Mish and Scuppernong are very susceptible to this disease.

Spraying to control black rot on muscadine grapes is not profitable, except during an unusually wet season.

BITTER ROT

Bitter rot, a fungus disease, is the major cause of muscadine fruit loss between the time of fruit set and harvest. Berries infected with bitter rot decay and shatter. (Some varieties of muscadines may shatter whether this disease is present or not.) On certain varieties, such as Topsail, the fungus may spot or fleck the leaves, as well as affect the berries.

In vineyards where bitter rot is severe, it sometimes is profitable to apply bordeaux mixture (4:4:100) a month before harvest followed in two weeks by a spray of captan or zineb.

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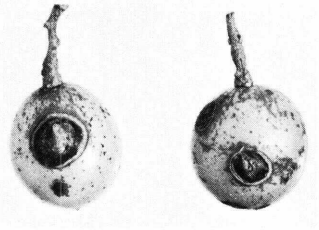

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Figure 9.—Effect of black rot on muscadine grapes.

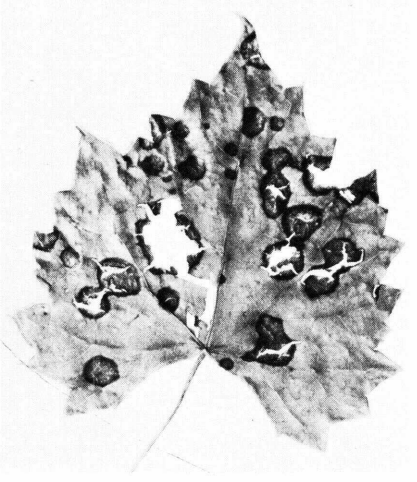

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Figure 10.—Spots caused by black rot fungus on leaf of muscadine grape.

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Figure 11.—Muscadine grape leaf spotted by Cercospora.

CERCOSPORA, OR ANGULAR, LEAF SPOT

Cercospora, or angular, leaf spot is a fungus disease. It is the most economically important disease affecting the leaves of muscadine grapes. All commonly grown varieties are susceptible, although Flowers, Scuppernong, and Thomas are more resistant than Creek, Howard, Hunt, and Stuckey. The leaf spot fungus does not attack the berries.

Infected leaves first show irregular, brown spots. The tissues surrounding the spots turn yellow. The spots enlarge and combine (fig. 11). Severe infection on the more susceptible varieties results in defoliation and impaired quality of the berries.

The disease can be easily controlled by applying bordeaux mixture (4:4:100) at 2- to 3-week intervals during the first half of the growing season. This treatment is necessary, however, only when the disease has become established in a vineyard. Because the spores overwinter on old fallen leaves, remove or plow under the leaves before new spring foliage appears.

INSECTS AND OTHER PESTS

GRAPE BERRY MOTH

Grapes are frequently damaged by larvae of the grape berry moth.[2] The larvae are active, greenish caterpillars about three-eighths inch long when full grown.

First-brood larvae feed in the blossoms or very young fruit clusters and in the newly formed berries. Larvae of later broods damage both the green and ripening berries (fig. 12, *A*), and often cause serious losses. One larva can injure several berries.

After feeding on the berries, the caterpillar cuts a small bit of leaf, folds it over, and constructs a cocoon within the fold (fig. 12, *B*).

[2] For the scientific names of insects mentioned in this bulletin, see p. 28.

The leaf folds containing the cocoons may remain attached to the leaves or they may break off and fall to the ground. Caterpillars of the first brood usually construct their cocoons on leaves that are on the vine during June or July. Those of the second brood usually drop to the ground and form their cocoons on small pieces of leaves under the grape trellis (fig. 12, *C*).

This insect overwinters in the cocoon (fig. 12, *D*). In late spring or early summer the inconspicuous brownish moths (fig. 12, *E*) emerge and lay their eggs on the grape stems or berries.

The grape berry moth is found throughout most of the Eastern States and is particularly troublesome in the region north of the Ohio River, east of the Mississippi River, and on through New England.

To control the grape berry moth, a combination of methods is sug-

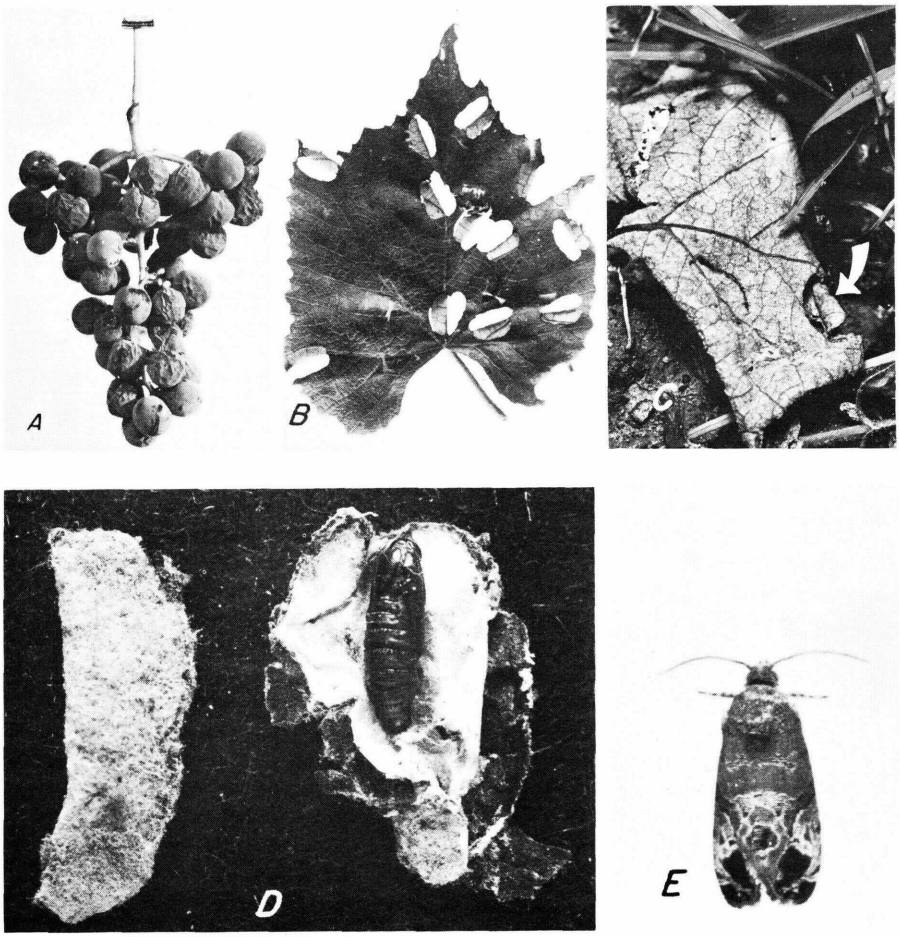

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Figure 12.—*A*, Cluster of grapes injured by grape berry moth; *B*, cocoons of moths on fallen grape leaf (cocoons are hidden under small flap of cut and folded leaf material); *C*, overwintering cocoon of grape berry moth (indicated by arrow) on ground under trellis; *D*, cocoon and pupa within an opened cocoon (about four times natural size); *E*, adult (about 4½ times natural size).

gested. In northern Ohio, bury overwintering cocoons under a layer of soil. This will aid in lowering the overwintering population to the point where sprays 3 and 4 or sprays 3, 4, and 5 (p. 26) will give good control or the general spray schedule (p. 26) will give better control than it would otherwise. Cultural control of the grape berry moth is described and illustrated in USDA Agriculture Information Bulletin No. 256, "Cultural Control of the Grape Berry Moth." If herbicides are used instead of cultural practices to control weeds, the general spray schedule may be required.

Insecticides recommended for control of grape berry moth are DDT, methoxychlor, carbaryl (Sevin), parathion, or azinphosmethyl (Guthion). Dosages and minimum waiting periods between the last insecticide application and harvest are given on page 25; apply DDT at the rate of 2 pounds of 50-percent wettable powder per 100 gallons of water. Observe the specified waiting periods closely to avoid excessive insecticide residues on the harvested fruit. The number of seasonal applications may vary from four to five, depending on the amount of insect damage the previous season. If grape berry moth infestations were light the previous season, spray 2 may be omitted. If early spring infestations were light during the current season, sprays 5 and 6 may be omitted. Sprays should be applied at the rate of 200 to 300 gallons per acre; the rate depends on the density of the foliage.

Do not apply DDT after spray 5. A fungicide to control diseases (p. 23) may be combined with the grape berry moth spray. A commercial sticker (p. 24) may be used at the manufacturer's recommendations with sprays 3 and 4 (p. 26), but omit it in subsequent sprays to reduce the residue on the fruit at harvest.

GRAPE LEAFHOPPERS

Grape leafhoppers, *Erythroneura comes* and related forms (fig. 13, *A* and *B*), are often abundant during the summer on the undersides of grape leaves. These small, jumping insects are white or pale-yellow and have red or yellow markings. They suck juice from the leaves and cause white blotches (fig. 13, *C*) that later change to brown. As a result, many leaves fall from the vines prematurely. This damage prevents normal vine growth and interferes with proper ripening of the fruit.

The insects overwinter as adults in protected places, usually in trash in or near vineyards. In early spring, the leafhoppers become active and feed on any green vegetation they can find. They are most abundant, however, on new grape leaves. There are two or three generations of these insects each season.

To control the grape leafhopper, spray with DDT, methoxychlor, malathion, or endosulfan (Thiodan). (See p. 25 for dosages.) One thorough application immediately after grape bloom is usually sufficient.

If overwintering leafhoppers are extremely abundant early in spring before grape bloom and are seriously injuring the new shoots, apply DDT, methoxychlor, malathion, or endosulfan.

If leafhoppers are abundant on muscadine or bunch grapes after harvest, spray with DDT.

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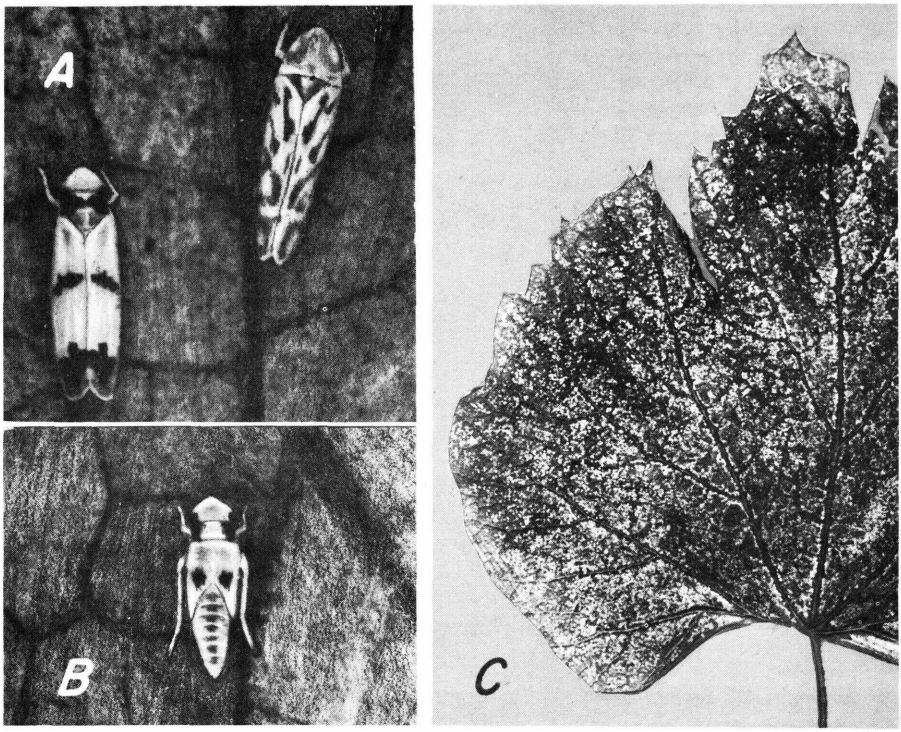

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Figure 13.—*A*, Adult grape leafhoppers; *B*, nearly full-grown nymph; *C*, mottled grape foliage injured by grape leafhoppers. Insects about 10 times natural size.

GRAPE ROOTWORM

The grape rootworm (larva) infests and damages the roots of grapevines (fig. 14, *A*).

The adult—a small, hairy, chestnut-brown beetle—appears in vineyards of such varieties as Catawba, Concord, and Niagara shortly after the blooming period. It feeds on the leaves, and makes chainlike patches or holes in them. Leaf damage is not important, however, compared to the larva's damage to the roots.

To control the grape rootworm adult, spray the plants with DDT. (See p. 25 for dosages.) The first and second sprays applied for grape berry moth control (p. 26) usually control the grape rootworm. If they do not, spray again about 10 days after the second spray.

ROSE CHAFER

In some localities in the Eastern States the rose chafer (fig. 15) causes severe damage early in the season to grape leaves, blossoms, and newly set berries. The beetles are general feeders; they damage many kinds of fruits and ornamental plants. They sometimes fly into a vineyard in large numbers and consume most of the foliage. Their feeding period lasts from 3 to 4 weeks.

This insect breeds largely in lawns and pastures. In its larval stage it is a small white grub.

For effective control of the rose chafer, apply a spray that contains 2 pounds of 50-percent DDT or methoxychlor wettable powder per 100 gallons of water. Spray as soon

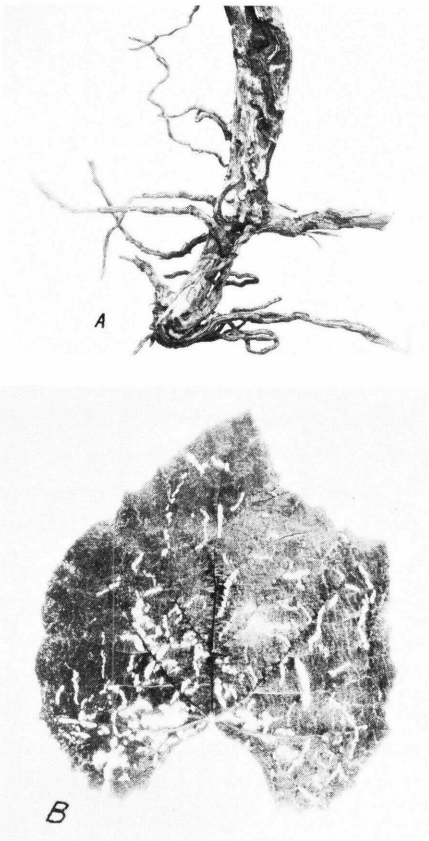

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Figure 14.—*A*, Injury by larvae of grape rootworm to roots of grapevine; *B*, feeding marks by adults on grape leaf.

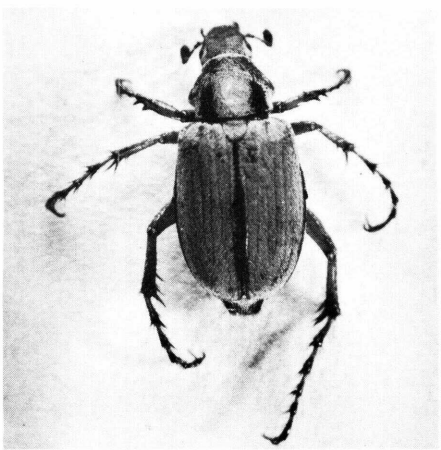

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Figure 15.—Adult female rose chafer. About two times natural size.

as the beetles appear; they can do considerable damage in a 24-hour period. Sometimes it may be necessary to spray while the grapes are in bloom. More often, a spray to control the rose chafer will be needed near the time of the first spray to control the grape berry moth. If so, a single application is enough for both insects. A fungicide (p. 23) may be added to this spray for disease control.

LEAF-EATING CATERPILLARS

Many kinds of caterpillars feed on grape leaves. The grape leaf folder is an active, grass-green caterpillar nearly three-fourths inch long. It rolls or folds the leaves (fig. 16) and then feeds in the fold.

The larva of the eight-spotted forester is about 1 inch long. It has black and orange stripes across its body and a distinct hump near its hind end (fig. 17).

Several species of hornworms, which are large caterpillars from 2 to 3½ inches long, often damage grape leaves, sometimes completely defoliating the vines. One of them is the achemon sphinx (fig. 18).

The leaf-eating caterpillars are usually controlled with DDT in sprays 2, 3, and 4 (p. 26). Because DDT does not control all species of these caterpillars, add lead arsenate to sprays 1 or 2 (p. 26). To prevent residue on the grapes, do not apply lead arsenate after the fruit appears. See page 25 for insecticide dosages.

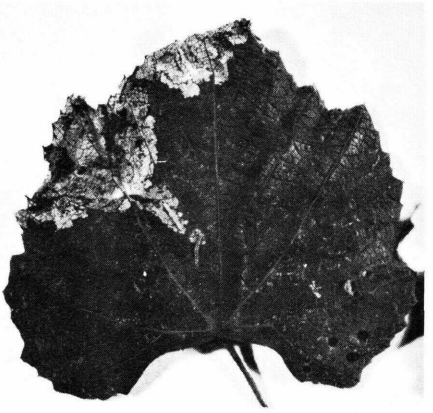
On muscadine or bunch grapes, a special post-harvest application of DDT may be necessary to control leaf-eating caterpillars.

GRAPEVINE APHID

In vineyards east of the Mississippi River, grapevine aphids are often found in large numbers during the summer on the young shoots

and leaves (fig. 19). This tiny dark-brown aphid is most likely to appear in dry weather and often disappears almost completely after a heavy rain. When the aphids are abundant, they may infest the fruit clusters and cause some of the grapes to drop. In fall, the aphids leave the grapevines and migrate to the blackhaw, where they spend the winter and spring; they return to the grapevines in early summer.

To control the grapevine aphid, spray the vines with parathion or malathion after the aphids appear. This may require application of a special spray but, if timing is convenient, one of these materials may be added to a spray in the general schedule. (See p. 25 for dosages.)

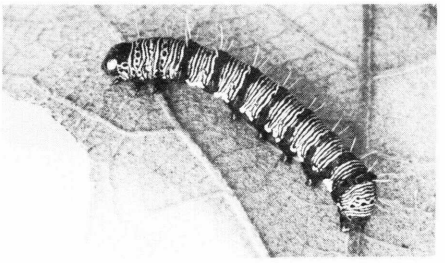


Sandusky–2405A

Figure 16.—Injury to grape leaf by grape leaf folder.

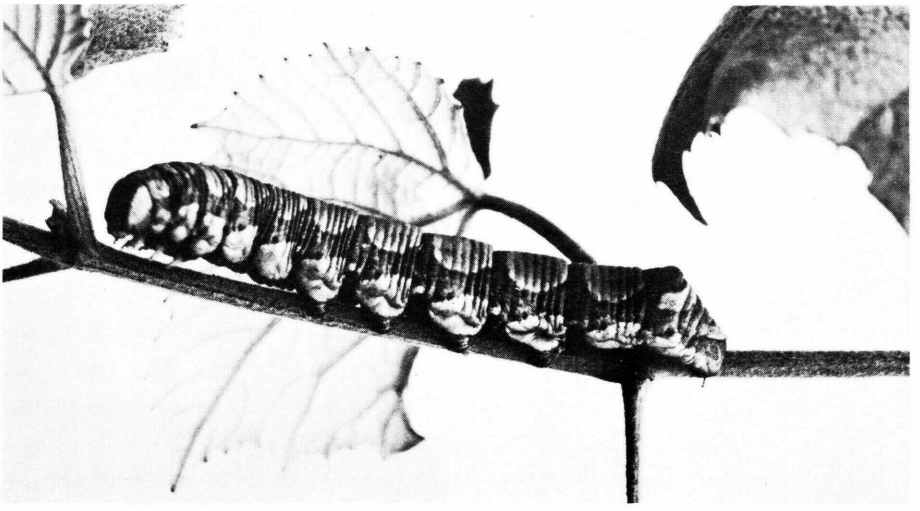
RED-BANDED LEAF ROLLER

Grapes may be damaged by larvae of the red-banded leaf roller throughout the Eastern States. It is a greenish caterpillar about three-quarters inch long when full grown. The caterpillar spins webbing in grape clusters and feeds on the berries while protected by the web (fig. 20). The first brood of caterpillars



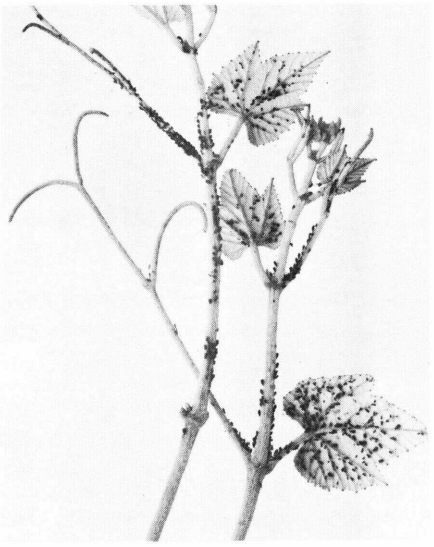
FrI–2831

Figure 17.—Larva of eight-spotted forester. About 1⅓ times natural size.



FrI–3420

Figure 18.—Achemon sphinx, one of the hornworms injuring grape leaves. About natural size.



FrI–2865

Figure 19.—Grapevine aphids on grape shoots and young leaves.

can appear as early as April, and there usually are two or three broods each year.

Sprays applied just before or after grape bloom reduce damage caused by later broods without leaving excessive harmful residues on the berries. The red-banded leaf roller is not readily controlled with DDT. Therefore, when this insect is a problem—

1. Include lead arsenate in spray 1 or 2 (p. 26), or in both of these sprays; *or*—

2. Include parathion in spray 2 or 3 at double the recommended dosage given on p. 25; *or*—

3. Include carbaryl in spray 2 or 3 at double the dosage given on p. 25.

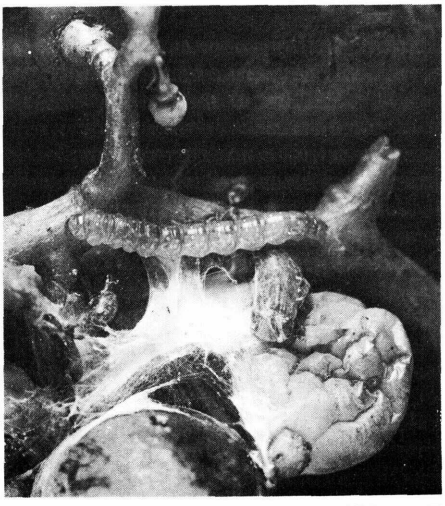
CLIMBING CUTWORMS

Several species of climbing cutworms occasionally damage grape buds when the buds begin to swell in early spring. Cutworms are stout, soft bodied and smooth, and are up to 1¼ inches long; they curl up tightly when disturbed. The worms eat the bud or make holes in it (fig. 21). They usually feed at night, when they come out from hiding under stones, rubbish, or weeds beneath the grape trellis. Damage is usually confined to localized areas in a vineyard and seldom occurs after the grape shoots begin to develop.

The best way to protect grapes from cutworm damage is to place 1⅓ ounces of 10-percent DDT dust on the lower part of the vine and on the ground below it. The cutworms contact the DDT as they climb on the vine and are killed by it. Other measures that will reduce cutworm damage include (1) a spray containing 2 pounds of 50-percent DDT wettable powder per 100 gallons of water just as the buds are swelling and (2) early cultivation under the vines in the infested part of the vineyard.

GRAPE FLEA BEETLE

The grape flea beetle adult is dark blue, shiny, and about three-sixteenths inch long (fig. 22). This insect overwinters as an adult in debris in or near vineyards in two-thirds of the Eastern States.



BN–11757X

Figure 20.—Larva of red-banded leaf roller on grape stem. About two times natural size.

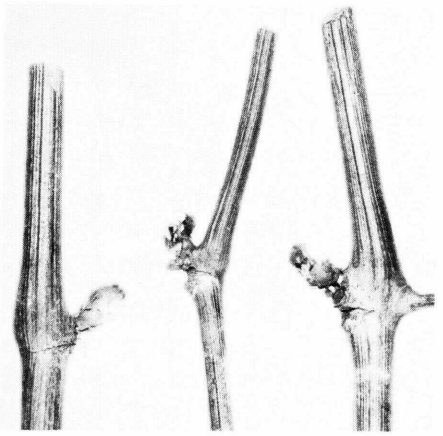
Early in spring, just as grape buds are swelling, it migrates to the grapevines and kills the buds by eating out their centers. As the secondary grape shoots develop, it lays eggs, and the worms (about one-fourth inch long when full grown) feed on the upper surface of the grape leaves.

This insect usually occurs in localized areas within a vineyard, particularly near woods or buildings. Its damage to grape buds closely resembles that caused by climbing cutworms. Be sure to determine which insect is causing the damage.

To protect against the flea beetle, spray with 4 pounds of 50-percent DDT wettable powder per 100 gallons of water just as the buds are swelling or when the shoots are 6 to 8 inches long. The spray controls the adults and the immature worms.

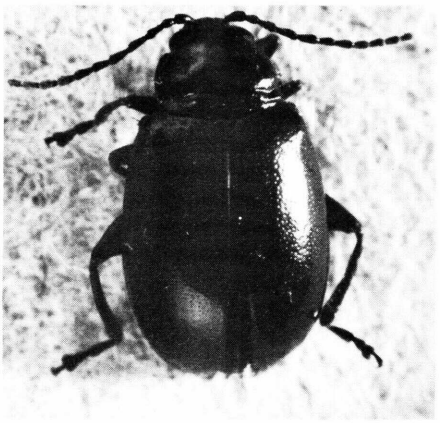
GRAPE CURCULIO

The grape curculio occurs from New England to Florida and west to the Mississippi Valley, but it is more prevalent and destructive in Ohio, West Virginia, and west to



BN–11751X

Figure 21.—Grape buds (two on right) destroyed by climbing cutworms. Bud on left not damaged. About three-fourths natural size.



BN–11743X

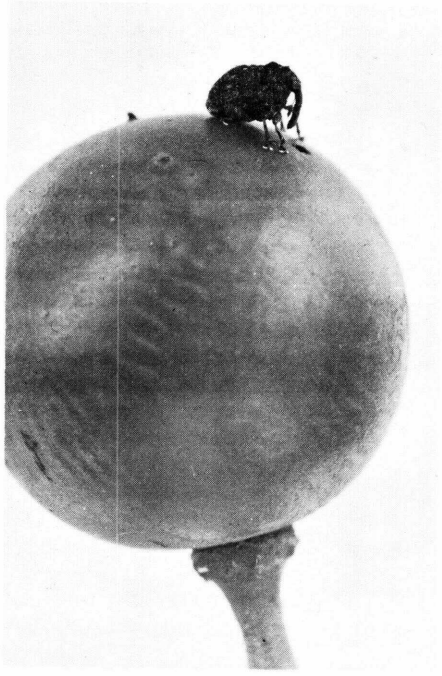
Figure 22.—Adult grape flea beetle. About 10 times natural size.

Illinois and Arkansas. The adult (fig. 23) is a broad, dark-brown snout beetle about one-tenth of an inch long. It feeds on the leaves of wild and cultivated grapes. The larva feeds on the flesh and seeds of the berries.

The adult hibernates in or near vineyards, particularly along the edge of woodlands. It becomes active in the spring—about the time the Concord is in bloom—and feeds on the leaves from 10 to 14 days before laying eggs. The damage appears as short, curved lines, usually in groups (fig. 24).

The eggs are placed in small shallow cavities that the adult cuts into the berries during July and August (fig. 25). They hatch in about 6 days. The larva develops inside the berries, and feeds on the flesh and seeds for about 3 weeks. When mature, it leaves the berries and constructs a small earthen cocoon, from which the adult beetle emerges in 3 or 4 weeks. After emerging, the adult feeds on grape leaves until cold weather when it goes into hibernation.

To control this insect, use DDT or parathion as for the grape berry moth (p. 26).



FrI–5363

Figure 23.—Adult grape curculio resting on grape near partially completed egg chamber.

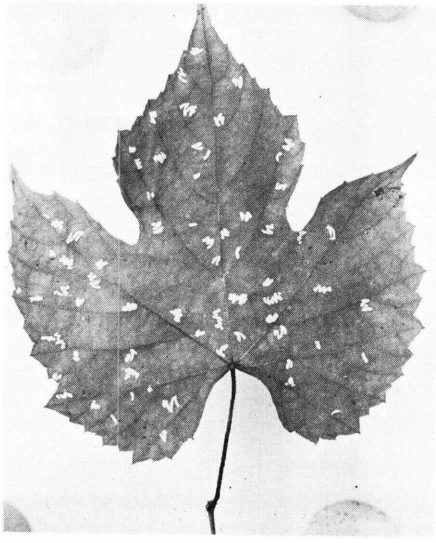


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Figure 24.—Feeding marks on grape leaf made by grape curculio.

GRAPE MEALYBUG

The grape mealybug is a whitish insect that sucks juice from the canes, stems, and berries of grapevines (fig. 26). There are two broods each year. The eggs are laid in early fall in a cottony mass under the loose bark of the grape trunk. The eggs hatch in late fall, but the young mealybugs do not leave the trunk until early spring. They then crawl out from under the bark and up onto the developing grape buds and shoots. These insects mature in early summer, and a second brood is started. It feeds mainly on the grape clusters.

Mealybugs secrete a sweetish honeydew fluid (fig. 27), in which a sooty mold develops. It gives the grapes an objectionable appearance and flavor. Damage by mealybugs also causes the cluster stems and berries to shrivel and fall.

To control the grape mealybug, use a single spray application of parathion at double the dosage given on p. 25. The spray may be applied 2 weeks before grape bloom or 6 to 8 weeks after it, but no later than 14 days before harvest. A malathion spray at the dosage given on p. 25 may be applied up to 3 days before harvest. Do not spray when mealybugs are under the bark of the grape trunk.

JAPANESE BEETLE

The Japanese beetle (fig. 28, *A*) is about one-half inch long. It is shiny metallic green and has coppery-brown wing covers. It appears on grapes early in the summer—about June 1 in parts of Virginia, June 15 near Philadelphia, and July 1 or later in New England.

For 4 to 6 weeks the beetles feed heavily on grape leaves (fig. 28, *B*), particularly those directly exposed to the sun, giving them a lacelike appearance. Badly damaged leaves fall.

The eggs are laid in the soil, most commonly in grassy areas, where the grubs develop.

To protect vineyards from the Japanese beetle, spray the vines thoroughly with DDT at 1⅓ times the regular dosage (p. 25). Ordinarily the DDT sprays applied to control the grape berry moth will take care of the Japanese beetle at the same time.

Other insecticides (p. 23) that may be used to control the Japanese beetle include carbaryl at 2 times the recommended dosage; malathion; methoxychlor, at 1½ times the recommended dosage; and parathion, at twice the recommended dosage. Do not use carbaryl in sprays containing lime.

A spray containing 3 pounds of derris or cube (4 percent of rotenone) per 100 gallons of water will repel the beetles for a few days and can be used as late as the day before harvest.

Dusting with hydrated lime will prevent some feeding.

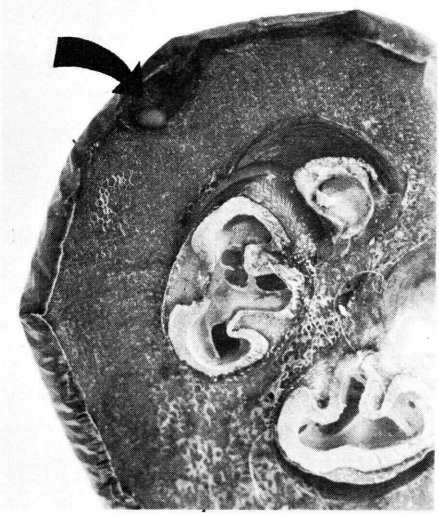

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Figure 25.—Egg and egg chamber of grape curculio.

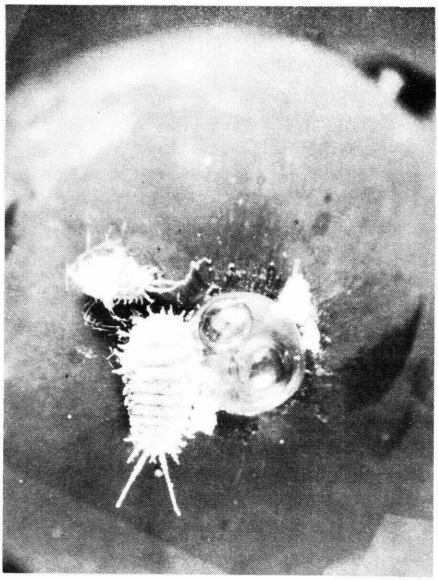

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Figure 26.—Grape mealybug (immature) feeding at junction of pedicle and grape berry. About seven times natural size.

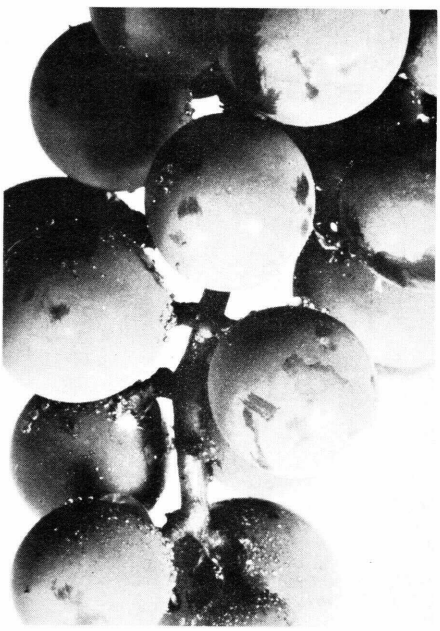

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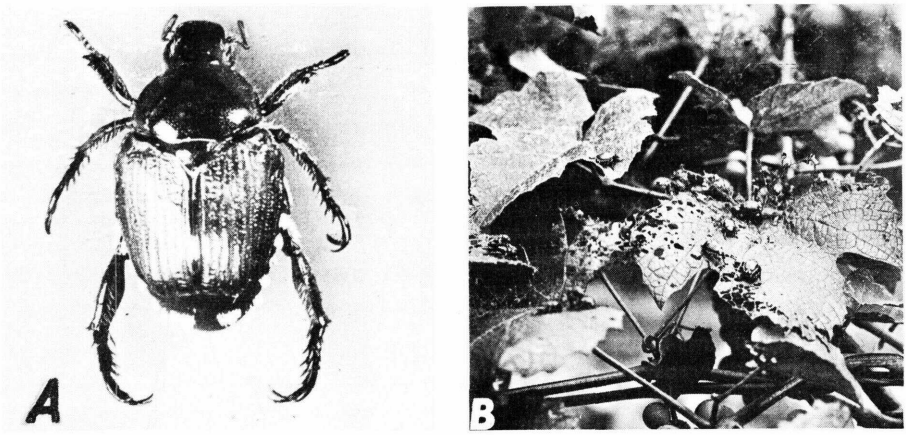
Figure 27.—Honeydew secretion on grape berries caused by feeding of grape mealybugs. About two times natural size.



BN–11748X and BN–11762

Figure 28.—Japanese beetle: *A*, Adult, enlarged; *B*, beetles feeding on grape leaf.

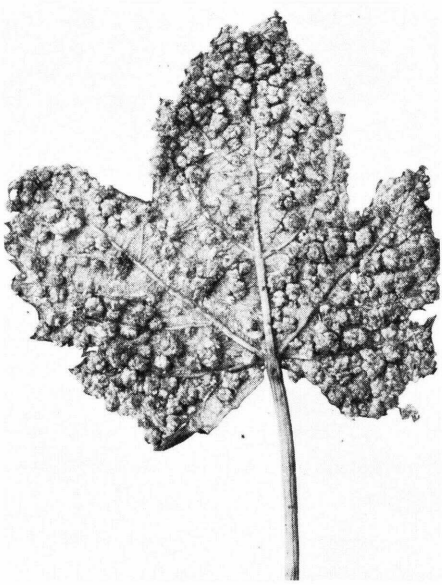
GALL MAKERS

Swellings, or galls, of various kinds occur on grapes as a result of attack by several unrelated insects. Gall insects appear early in the season, sometimes 3 or 4 weeks before grape bloom. Most of them have several broods during the season. The infestations are limited to small areas in a vineyard, and damage to the vines or crop is not often serious.

Leaves covered with galls (fig. 29) may indicate an infestation by the grape phylloxera, a small aphidlike insect that attacks both roots and foliage. Root damage is particularly serious on vinifera varieties of grapes. Wild grapes in the Eastern States and varieties developed from them differ in their immunity to gall injury and thrive in spite of it.

To control leaf infestations of phylloxera, apply lindane when the galls first appear and again 7 to 10 days later. See page 25 for dosage. Chemical procedures for control of the root-infesting forms have not proved satisfactory.

The term "tomato gall" is used to describe masses of irregular succulent galls often found on wild and cultivated grapes (figs. 30 and 31). They are caused by *Lasioptera vitis*, *Dasineura vitis*, and other species. The galls may be on the leaves, leafstalks, tendrils, or stalks of the fruit clusters and are greenish yellow to reddish. They are divided into tiny cells, in each of which an orange-yellow larva, or grub, develops. The adults are tiny flylike insects known



FrI–3961

Figure 29.—Leaf galls of grape phylloxera.

as gnats, or midges. They appear in the spring in time to attack new, tender growth.

Pear-shaped, hazelnutlike galls (fig. 32), which are less than an inch in diameter, first greenish and then reddish as the season advances, are caused by the grape apple gall maker. These galls have exterior depressions extending lengthwise, which are divided into cells in which the bright-yellow larvae develop.

An enlargement on the cane—usually just above a lower joint, about twice the diameter of the cane, and 1 or 2 inches long—may result from a puncture by the grape cane gall maker, a small reddish-brown weevil. An egg is placed in this puncture, and several additional punctures may be made above the original one, but no additional eggs are deposited. The larva feeds in the pith, burrowing up and down the shoot. The beetle emerges in midsummer. The injured canes continue to grow and become enlarged at the puncture, but unless they are broken, little harm results.

Grape leaves sometimes are covered with slender galls, which are about one-third inch long and reddish to green. These trumpet, or grape tube, galls are caused by a small midge, or gnat, known as *Cecidomyia viticola*. The larva, or grub, within the gall is pale orange.

Growers of vinifera grapes should plant vines that are on phylloxera - resistant rootstocks. Growers of American varieties will seldom find the grape phylloxera of sufficient economic importance to require control measures.

BEES, WASPS, AND BIRDS

Bees and wasps attack grapes through injuries caused by other insects, birds, and by diseases, or

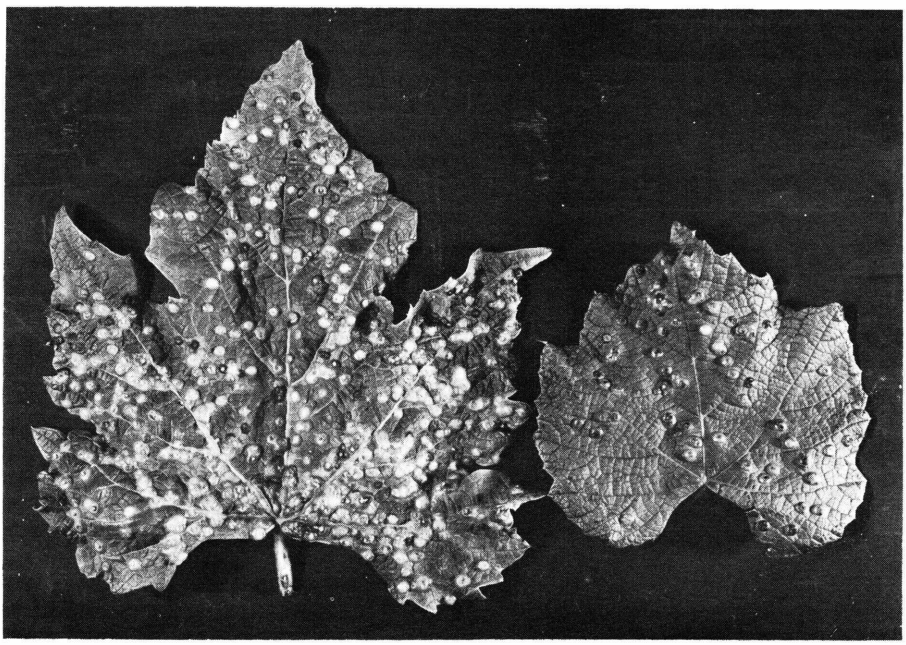


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Figure 30.—Grapevine tomato galls on grape leaves.

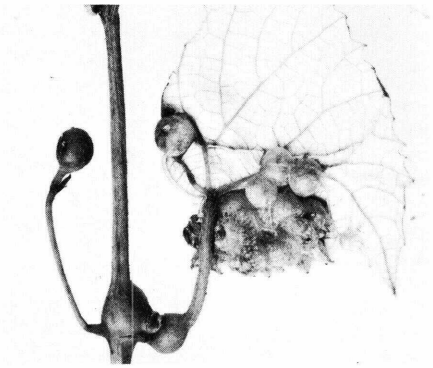

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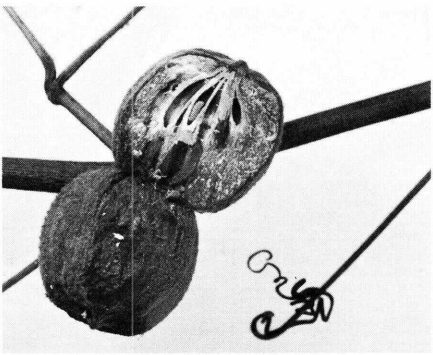
Figure 31.—Grapevine tomato galls on grape leaf and tendril.



FrI–3294

Figure 32.—Grape apple galls.

through splits in the skins of overripe berries. Bees and wasps are not able to break the skin of sound grapes with their mouth parts. When the skin has been broken, however, they can quickly make the fruit worthless.

To prevent damage by bees and wasps, control other insects and diseases that injure the skin of grapes. Pick grapes before they are overripe.

During seasons when grapes mature and ripen early, small migrating birds may peck tiny holes in the grapes. Bees, wasps, pomace flies, and bacteria then can spoil the fruit. Large birds, such as starlings, robins, crows, and sparrows, eat most of the grapes and leave practically nothing to spoil.

PRECAUTIONS

Pesticides used improperly can be injurious to man, animals, and plants. Follow the directions and heed all precautions on the labels.

Store pesticides in original containers under lock and key—out of the reach of children and animals—and away from food and feed.

Apply pesticides so that they do not endanger humans, livestock, crops, beneficial insects, fish, and wildlife. Do not apply pesticides when there is danger of drift, when honey bees or other pollinating insects are visiting plants, or in ways that may contaminate water or leave illegal residues.

Avoid prolonged inhalation of pesticide sprays or dusts; wear protective clothing and equipment if specified on the container.

Parathion and azinphosmethyl (Guthion) are highly toxic and may cause death if swallowed, inhaled, or absorbed through your skin. These insecticides should be applied only by persons who are thoroughly familiar with their hazards and who will assume full responsibility for their safe use and comply with all precautions on the container labels.

Endosulfan (Tiodan) and lindane, although less toxic than parathion and azinphosmethyl, can be absorbed through the skin in harmful amounts. Follow precautions on the label carefully when using these insecticides. Do not use endosulfan on Concord grapes; it can severely damage them.

Methoxychlor, malathion, lead arsenate, carbaryl (Sevin), DDT, and all of the fungicides mentioned in this publication are among the less hazardous pesticides to handle, as long as label directions are followed and safe handling procedures are used.

If your hands become contaminated with a pesticide, do not eat or drink until you have washed. In case a pesticide is swallowed or gets in the eyes, follow the first aid treatment given on the label, and get prompt medical attention. If a pesticide is spilled on your skin or clothing, remove clothing immediately and wash skin thoroughly.

Do not clean spray equipment or dump excess spray material near ponds, streams, or wells. Because it is difficult to remove all traces of herbicides from equipment, do not use the same equipment for insecticides or fungicides that you use for herbicides.

Dispose of empty pesticide containers promptly. Have them buried at a sanitary land-fill dump, or crush and bury them in a level, isolated place.

NOTE: Some States have restrictions on the use of certain pesticides. Check your State and local regulations. Also, because registrations of pesticides are under constant review by the U.S. Department of Agriculture, consult your county agricultural agent or State Extension specialist to be sure the intended use is still registered.

SPRAY MATERIALS

The spray materials mentioned in this bulletin can usually be obtained from local agricultural supply houses. Buy spray materials from a reputable manufacturer.

FUNGICIDES

Bordeaux Mixture

Bordeaux mixture is a fungicide that is best prepared by the grower and used within a few hours. The ingredients are copper sulfate (bluestone), hydrated lime, and water.

Use 2 to 8 pounds each of copper sulfate and lime per 100 gallons of water; the amount depends on the time of year and the diseases to be controlled. (See spray schedule p. 26.) Use the type of copper sulfate that dissolves readily in water. The most convenient and available type of lime for the spray is hydrated lime, such as is used in the building trade. Use only fresh lime; old lime is less effective, does not mix well, and tends to clog spray nozzles.

To prepare bordeaux mixture in a spray tank, fill the tank half full with water, start the agitator in the tank, and add the lime. Allow the agitator to mix the lime thoroughly in the tank, then add the copper sulfate. Fill the tank with water.

Bordeaux mixture may be used at any time up to harvest. Since it leaves a visible film on the fruit, other forms of copper are generally preferred for the last spray or two.

Other Spray Materials Containing Copper

Bordeaux mixture and several other spray materials that have a higher metallic copper content than the standard copper sulfate may be obtained commercially. If these commercial materials are used to make a bordeaux or a copper-lime mixture for grape sprays, smaller quantities are required. Be sure to follow the manufacturer's directions. It is important that the amount of hydrated lime be equivalent to the amount (by weight) of copper spray material used. Several "fixed" coppers are available. Since the copper content varies, follow directions on the label carefully.

Ferbam, Zineb, and Captan

Ferbam, zineb, and captan are organic fungicides. You may mix these fungicides with any of the insecticides mentioned in this bulletin, but not with bordeaux mixture or lime-sulfur fungicides.

See page 25 for recommended dosages and minimum days from last application to harvest.

INSECTICIDES

Lead Arsenate

Lead arsenate is a powdery material that is used as a stomach poison for insects. In its pure form, this chemical is white, but when sold for insecticides it is usually pink.

When using lead arsenate, combine it with an equal amount of hydrated lime or other safener. Do not apply lead arsenate after grapes begin to form.

DDT

DDT sprays are used throughout the eastern grape-growing region to control many kinds of grape insects. DDT mixes readily with water. It may be used in combination with fungicides, such as bordeaux mixture or ferbam, or with lead arsenate or parathion.

Do not use DDT on grapes later than 40 days before harvest, or after the second cover spray in the general spray schedule (p. 26).

Methoxychlor

Methoxychlor is closely related to DDT and can be substituted for it in the control of the grape berry moth, the Japanese beetle, the rose chafer, and grape leafhoppers. Methoxychlor may be mixed with other insecticides and with fungicides recommended for use on grapes. It is markedly less toxic to warm-blooded animals than DDT and one of the safest insecticides to handle. Do not use methoxychlor later than 14 days before harvest.

Lindane

Lindane is effective in controlling the grape phylloxera when it attacks leaves. To avoid possible off-flavor in grapes, do not use lindane later than 1 month after bloom.

Parathion

Commercial parathion is available in emulsion or powder form. Use it to control the grape berry moth, the grape mealybug, the grapevine aphid, the Japanese beetle, the red-banded leaf roller, the grape curculio, and mites on grapes.

Parathion wettable powders mix readily with water. Parathion may be used in combination with ferbam, DDT, or lead arsenate. But lime, bordeaux mixture, and alkaline substances reduce its effectiveness. Do not use parathion later than 14 days before harvest.

Azinphosmethyl (Guthion)

Azinphosmethyl is a phosphorus insecticide that has a longer residual effect than parathion. Use it to control the grape berry moth. It is available in both powder and emulsion form. You may mix azinphosmethyl with the commonly used insecticides and fungicides. Do not use it later than the day before harvest. Do not use it in more than three applications during the growing season.

Malathion

Malathion is a phosphorus insecticide and is relatively low in toxicity to mammals. It is comparatively safe to handle. It may be used for controlling grapevine aphids, grape leafhoppers, grape mealybugs, spider mites, grapevine tomato gall insects, and Japanese beetles. Do not use malathion within 3 days of harvest.

Carbaryl (Sevin)

Carbaryl is a carbamate insecticide that is effective against the grape berry moth, Japanese beetle, and red-banded leaf roller. Do not use carbaryl in sprays containing lime. Carbaryl can be used as late as the day before harvest.

Endosulfan (Thiodan)

Endosulfan is a chlorinated insecticide of intermediate toxicity. It is most effective against leafhoppers and aphids. Do not use endosulfan later than 7 days before harvest. Do not use endosulfan on Concord grapes.

SPREADERS AND STICKERS

Certain materials can be added to grape sprays to make them spread more evenly and adhere longer after they have dried. Although these spreaders and stickers are not always necessary, they increase the coverage and the periods of effectiveness of the early

sprays when grape foliage is limited. This is particularly so when heavy concentrations of bordeaux mixture or lead arsenate are used. To avoid excessive spray residues at harvest, do not use stickers after the first cover spray or 30 days after bloom.

Various spreaders and stickers may be obtained commercially. Follow the manufacturer's directions—usually from 1 pint to 1 quart for each 100 gallons of spray. The emulsified, or miscible, oil spreaders and stickers are generally preferred. Add these materials to the spray mixtures last. They mix readily by ordinary tank agitation.

GENERAL SPRAY SCHEDULE FOR GRAPES

Because of the long growing season and the frequency of rains in Florida and other South Atlantic and Gulf States, the general spray schedule (p. 26), which is effective in controlling diseases in the region north of the Ohio River and east to the Atlantic coast, is inadequate. Therefore, if your vineyard is south of Virginia, Tennessee, and Missouri, consult your county agricultural agent or write to your State college of agriculture for advice about the timing and number of spray applications needed.

Although four or five applications of fungicides may give satisfactory control of black rot, downy mildew, and anthracnose in northern areas, the number of applications may need to be doubled in the South to obtain satisfactory results.

It cannot be too strongly emphasized that early sprays in the general spray schedule are necessary. Infection of leaves and canes must be prevented if clean fruit is to be produced. Little can be accomplished if spraying is postponed until the fruit begins to rot or insect damage appears.

PESTICIDES FOR CONTROL OF DISEASES AND INSECTS OF GRAPES [1]

Fungicide or insecticide	Formulation [2]	Maximum amount of active ingredient to apply		Minimum days from last application to harvest
		Pounds per 100 gallons of water	Pounds per acre	
Fungicides:				
Captan	WP	1	3	0
Ferbam	WP	1.5	4.5	7
Zineb	WP	1	3	7
Insecticides:				
Azinphosmethyl (Guthion)	WP or EC	.25	.75	1
Carbaryl (Sevin)	WP	1	3	0
DDT	WP	.75	2.25	40
Endosulfan (Thiodan)	WP	.5	1.5	7
Lead arsentate	WP	3	9	
Lindane	WP or EC	.3	1	
Malathion	WP or EC	.9	2.75	3
Methoxychlor	WP	1	3	14
Parathion	WP or EC	.15	.5	14

[1] See discussions of specific diseases and insects in the text before selecting pesticide. Also see "Spray Materials" (pp. 23 to 25) and "Precautions," p. 22.
[2] EC=emulsifiable concentrate; WP=wettable powder.

GENERAL SPRAY SCHEDULE FOR CONTROL OF MAJOR DISEASES AND INSECTS OF GRAPES[1]

Spray	Time of application	Materials[2]	Disease or insect	Remarks
1	When new shoots are 7 to 10 inches long.	Ferbam, bordeaux mixture (6:6:100), or zineb.	Black rot Dead arm	In the South, or where black rot is serious, apply extra spray of bordeaux mixture (8:8:100) or ferbam when young shoots are 1 to 2 inches long. See text for special sprays for control of dead arm. Add DDT to this spray if overwintering grape leafhoppers or grape flea beetles are severe.
2	3 to 5 days before bloom	DDT and ferbam, bordeaux mixture, or zineb.	Black rot Grape berry moth Japanese beetle Rose chafer	If early downy mildew is a problem, use bordeaux mixture (4:4:100) or zineb rather than ferbam. If grapes bloom while applying this spray, keep spraying pressure at 350 pounds per square inch or below. Add lead arsenate to this spray if red-banded leaf rollers are present.
3	Immediately after bloom (petal fall).	DDT, methoxychlor, carbaryl (Sevin), azinphosmethyl (Guthion), or parathion; or parathion in combination with DDT, methoxychlor, or carbaryl; and ferbam, bordeaux mixture, or zineb.	Black rot Downy mildew Grape berry moth Grape leafhoppers Grape rootworm Japanese beetle Red-banded leaf roller.	If red-banded leaf rollers are present, add a recommended insecticide to this spray (p. 23). If grape leafhoppers are abundant, malathion or endosulfan may be used (p. 23). If downy mildew is a problem, use bordeaux mixture (4:4:100) or zineb rather than ferbam. Do not use parathion or azinphosmethyl in small home plantings.
4	10 to 15 days after spray 3 (first cover).	Same as for spray 3	Black rot Grape berry Grape leafhoppers Grape rootworm Japanese beetle	Apply 250 to 300 gallons per acre. During wet periods repeat this spray weekly.
5	35 to 45 days after grape bloom (second cover).	Same as for spray 3	Downy mildew Grape berry moth	Spraying before eggs hatch is important. If downy mildew is present, use bordeaux mixture (2:2:100) or zineb.

6-----	10 to 15 days after spray 5	Same as for spray 3, except that azinphosmethyl should not be used if it has been used in three earlier applications.	Downy mildew----- Grape berry moth--- Grape mealybug-----	Apply at least 40 days before grape harvest if DDT is used. See p. 18 for grape mealybug control. If downy mildew is present, use bordeaux mixture (2:2:100), fixed copper, or zineb.

[1] Modifications may be necessary to adapt this schedule to the needs of each locality. More detailed spray schedules for local areas may be obtained from State extension or county agricultural agents. Alternate spray materials are described in the text. See "Precautions" (p. 22) and pesticide restrictions in "Spray Materials" (pp. 23 to 25).

[2] Formulations and dosages are given on p. 25 unless shown in parentheses following specific materials.

CAUSAL ORGANISMS OF GRAPE DISEASES

Disease	*Causal organism*
Anthracnose or bird's-eye rot	*Elsinoë ampelina*
Bitter rot	*Melanconium fuligineum*
Black rot	*Guignardia bidwellii*
Cercospora leaf spot or angular leaf spot	*Mycosphaerella angulata*
Crown gall	*Agrobacterium tumefaciens*
Dead arm	*Phomopsis viticola*
Downy mildew	*Plasmopara viticola*
Powdery mildew	*Uncinula necator*
Ripe rot	*Glomerella cingulata*

COMMON AND SCIENTIFIC NAMES OF INSECT PESTS OF GRAPES

Common name	*Scientific name*
Achemon sphinx	*Pholus achemon*
Climbing cutworms	*Feltia* and *Agrotis*
Eight-spotted forester	*Alypia octomaculata*
Grape apple gall maker	*Schizomyia vitispomum*
Grape berry moth	*Paralobesia viteana*
Grape cane gall maker	*Ampeloglypter sesostris*
Grape curculio	*Craponius inaequalis*
Grape flea beetle	*Altica chalybea*
Grape leaf folder	*Desmia funeralis*
Grape leafhopper	*Erythroneura comes*
Grape mealybug	*Pseudococcus maritimus*
Grape phylloxera	*Phylloxera vitifoliae*
Grape rootworm	*Fidia viticida*
Grapevine aphid	*Aphis illinoisensis*
Japanese beetle	*Popillia japonica*
Midges or gnats	*Cecidomyia viticola* *Dasineura vitis* *Lasioptera vitis*
Pomace fly	*Drosophila melanogaster*
Red-banded leaf roller	*Argyrotaenia velutinana*
Rose chafer	*Macrodactylus subspinosus*

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